

Thesis
K51

Library
U. S. Naval Postgraduate School
Annapolis, Md.

A GUIDE LIST FOR THE STUDENT

A GUIDE

Selection in the Faculty

OF

Persons Outgoing

BY

James Taylor Kirk

In Partial Fulfillment of the

Requirements for the Degree

OF

Master of Science in Industrial Engineering

June, 1908

2100000
1950

A CHECK LIST FOR THE THERBLIG HOLD
A Thesis
Submitted to the Faculty
of
Purdue University
by
Eugene Taylor Kirk
In Partial Fulfillment of the
Requirements for the Degree
of
Master of Science in Industrial Engineering
June, 1950

Thesis
251

A THESIS SUBMITTED TO THE FACULTY OF THE
UNIVERSITY OF TORONTO
IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE IN INDUSTRIAL ENGINEERING
JUNE, 1950

ACKNOWLEDGMENTS

The author is deeply indebted to Professor H. T. Amrine under whose supervision this study was undertaken and whose guidance and help have been of inestimable value.

To Professors M. E. Mundel, W. J. Richardson and O. Musgrave, the author is grateful for their helpful suggestions.

To the staff and personnel of The Duncan Electric Company, Lafayette, Indiana, The Steven A. Young Company, Flora, Indiana, and the Naval Ordnance Plant, Indianapolis, Indiana, the author is obligated for the courtesies and assistance extended to him.

Finally to my wife, for her patience and understanding help, I shall ever be grateful.

ACKNOWLEDGMENTS

The author is deeply indebted to Professor
H. T. Lakin under whose supervision this study was
undertaken and whose kindness and help have been of
incalculable value.

To Professor W. K. Wendell, W. L. Richards and
O. Knapp, the author is grateful for their helpful
suggestions.

To the staff and personnel of The Kansas Electric
Company, Lawrence, Kansas, The Great A. Young Company,
Topeka, Kansas, and the Hotel Wisconsin Hotel, Indianapolis,
Indiana, the author is obligated for the courtesies and
assistance extended to him.

Finally to my wife, for her patience and understand-
ing help, I shall ever be grateful.

TABLE OF CONTENTS

	Page
LIST OF FIGURES	iv
ABSTRACT	v
INTRODUCTION	1
PURPOSE	4
APPROACH TO THE PROBLEM	5
PREPARATION OF CHECK LIST	9
DISCUSSION OF CHECK LIST	13
CONCLUSIONS	28
BIBLIOGRAPHY	29

TABLE OF CONTENTS

Page	
iv	LIST OF FIGURES
v	SYNOPSIS
i	INTRODUCTION
4	DEFINITIONS
8	APPENDIX TO THE FOREWORD
9	SYNOPSIS OF THE FIRST PART
12	SYNOPSIS OF THE SECOND PART
15	SYNOPSIS OF THE THIRD PART
18	SYNOPSIS OF THE FOURTH PART
20	SYNOPSIS OF THE FIFTH PART
22	SYNOPSIS OF THE SIXTH PART

LIST OF FIGURES

Figure	Page
1. Foot Operated Vise	14
2. Foot Operated Fixture For Holding Cylindrical Components	14
3. Wooden Fixture For Holding Threaded Section Of Double Faucet During Assembly Of Apron And Valve Stems	15
4. Fixture For Holding Workpiece In Vertical Position	17
5. Example Of An Indexing Fixture	18
6. Another Example Of An Indexing Fixture .	19
7. Details Of Clip And Bracket End Of Fig.6	20
8. Method Of Breaking Cross Section Into Component Parts	22
9. Fixture For Faucet Sub Assembly	22
10. Details Of Fixture Shown In Fig. 9	23
11. Fixture Incorporating Sliding Of Components	24
12. Another Fixture Incorporating Sliding Of Components	25

LIST OF FIGURES

Figure		Page
1.	Foot Operated Valve	12
2.	Foot Operated Fixture For Holding	
	Cylindrical Components	14
3.	Wooden Fixture For Holding Pressed	
	Section Of Double Levered Spring Assembly	
	Of Arms And Valve Spools	15
4.	Fixture For Holding Springs In	
	Vertical Position	17
5.	Example Of An Inserting Fixture	18
6.	Another Example Of An Inserting Fixture	19
7.	Details Of Grip And Bracket And Of Figs. 5	20
8.	Method Of Breaking Open Section Into	
	Component Parts	22
9.	Fixture For Remounting Sub Assembly	23
10.	Details Of Fixture Shown In Fig. 9	23
11.	Fixture Incorporating Division Of	
	Components	24
12.	Another Fixture Incorporating Sliding	
	Of Components	25

ABSTRACT

Often in industrial situations the non-productive therblig HOLD occurs and usually can profitably be eliminated by resorting to the use of some device to maintain the workpiece in a fixed position and location. This is especially true in hand operations such as assembly work and operations capable of being made bi-manual, where the versatility of the hand can be used to do more productive work.

The purpose of this study is to attempt to develop a check list which will facilitate a systematic approach to the problem of selecting or designing devices to eliminate the therblig HOLD.

A survey of texts on tool design and motion and time study as well as periodicals established basic principles that apply to fixtures which hold a workpiece while an operation is being performed. Using these as a guide a check list has been developed to apply to the therblig HOLD when it occurs. The list is arranged in a sequence so as to facilitate a logical approach to the problem of dealing with the situation and should provoke thought in such a fashion as to lead to the selection of a more suitable device to eliminate HOLD.

Often in industrial situations the non-productive time with HOLD occurs and usually can profitably be eliminated by resorting to the use of some device to maintain the workpiece in a fixed position and location. This is especially true in hand operations such as assembly work and operations on the side of being made in-hand, where the versatility of the hand can be used to its most productive work.

The purpose of this study is to develop a device which will facilitate a systematic approach to the problem of reducing or eliminating delays in eliminating the HOLD.

A survey of data on hand design and motion study as well as systematic approaches to the problem of reducing or eliminating delays in eliminating the HOLD will be presented. Being there as a guide a device has been developed to apply to the problem of reducing or eliminating the HOLD. The data is arranged in a sequence as to the elimination and should provide insight in such a fashion as to lead to the selection of a more suitable device to eliminate HOLD.

INTRODUCTION

In industry and other fields today the acceptance and application of Motion and Time Study is becoming more widespread. While Motion and Time Study is not a cure-all for existing faults it is a useful tool of efficient management.

When Motion and Time Study is applied, a logical procedure should be followed. Such a procedure in the case of its application for methods improvement should include (1) making a record of the work method, present or proposed, (2) analyzing the method and (3) working out an improved method.

One systematic means of recording the work method is by the use of therbligs. After the method is recorded the individual therbligs may be questioned as by the list of basic rules¹ below:

1. Try to have both hands doing the same thing at the same time or balance the work of the two hands.
2. Try to avoid the use of the hands for holding.
3. Relieve the hands of work whenever possible.
4. Eliminate as many therbligs or as much of a therblig as possible.
5. Arrange the therbligs in the most convenient order.
6. Combine therbligs when possible.
7. Standardize method and train worker.

Often in an analysis the therblig HOLD will appear.

"Hold refers to the retention of an object after it has been

1. Mundel, M.E., Systematic Motion and Time Study; New York, Prentice-Hall, Inc., 1947, pg. 127

INTRODUCTION

In industry and other fields today the systematic and application of Motion and Time Study is becoming more widespread. While Motion and Time Study is not a cure-all for existing trouble it is a useful tool of efficient management. When Motion and Time Study is applied, a logical procedure should be followed. Such a procedure in the case of its application for methods improvement should include (1) making a record of the work method, present or proposed, (2) analyzing the method and (3) working out an improved method.

The systematic means of recording the work method is by the use of checklists. After the method is recorded the individual checklist may be questioned as by the list of points below:

1. Try to save both hands doing the same thing as the same time or balance the work of the two hands.
 2. Try to avoid the use of the hands for holding.
 3. Release the hands of work whenever possible.
 4. Eliminate as many handlings as we can of a material as possible.
 5. Arrange the handlings in the most convenient order.
 6. Combine handlings when possible.
 7. Eliminate method and waste motion.
- When in an analyze the checklist will appear:
- "Hold refers to the retention of an object after it has been

grasped, no movement of the object taking place."² "HOLD begins when movement of part or object, which hand or body member has under control, ceases, consists of holding an object in a fixed position and location and ends with any movement."³ By movement is meant deliberate and intentional changing of position or location. From its definition HOLD may be detected even without resorting to a formal and detailed method breakdown.

Under most circumstances HOLD is undesirable since the hand is a poor and nonproductive holding device. If, as is often the case, one hand merely holds the workpiece in position while the other performs the useful work, a large percentage⁴ of the productive potential of the worker is lost. Also, holding is tiresome to the worker. By the use of a suitable holding device it is often possible to balance the hand patterns of the worker leading to higher production and an improved method.

Under unusual conditions, such as extremely short duration of the therblig, where the time of loading and unloading a holding device overbalances the time of HOLD it may be more economical to retain this therblig than to eliminate it.

2. Barnes, R.M., Motion and Time Study; New York, John Wiley & Sons, Inc., 1949, pg. 98

3. Mundel, M.E., Ibid, pg. 104

4. 41%, Ischinger, E.Jr., An Analysis of Some Differences Between One and Two Handed Work, Thesis, Purdue University, June, 1950

Usually it appears because it is the "natural thing to do" or the worker performing the job does not take a sufficiently detached view to question its existence.

In resorting to the use of some device to eliminate HOLD the cost of design, material and labor must be considered and must be offset by the saving made possible by the use of the device. Often it is possible to make a simple, inexpensive device for a short run job and by so doing reap the benefits of a better method.

In such reference works as Modern Shop Practice⁵ may be found examples of jigs and fixtures for performing certain specific machining work which are of use in the design of new tools for comparable jobs. In addition the numerous texts on tool design discuss the principles of fixture design.

Based on the above it is felt that it would be beneficial to develop a systematic method of approach to the matter of analyzing the occurrence of the therblig HOLD. Often much time is consumed in "dreaming-up" devices that could be saved by a systematic approach.

5. Modern Shop Practice, American Technical Society; Chicago, 1940, Vol. 4

usually it appears because it is the "natural" thing to do, or the worker performing the job does not take a sufficiently detached view to question his existence.

In counseling to the use of some device to eliminate the sort of fatigue, embodied and labor must be considered and must be offset by the machine made possible by the use of the device. Often if it possible to make a simple, inexpensive device for a short run job and by no doing very the benefits of a better method.

In some reference works as Modern Shop Practice and in some examples of time and fixtures for performing certain specific machining work which are of use in the design of new tools for comparable jobs. In addition the numerous facts on tool design discuss the principles of fixture design.

Based on the study it is felt that it would be beneficial to develop a systematic method of approach to the matter of analyzing the occurrence of the working shift. After such time is consumed in "drawing-up" devices that could be saved by a systematic approach.

PURPOSE

The purpose of this study is to attempt to develop a check list which will facilitate a systematic approach to the problem of selecting or designing devices to eliminate the therblig HOLD.

REPORT

The purpose of this study is to develop a
-to a specific list of individuals -
referred to as the program of action or
action plan to eliminate the harmful effects

APPROACH TO THE PROBLEM

To establish a clearer concept of the limits of HOLD the following amplification is undertaken. In the field of materials handling, pallets and skids are considered holding devices. Often such devices as pliers and wrenches "hold" workpieces but should usually be properly classified as tools being "used". Other devices for holding are known as jigs but these are usually associated with precision or machining work in which the hand could seldom properly hold the workpiece. Fixtures, which may be defined as "devices for holding work while an operation is being performed",⁶ are distinguished from jigs by the fact that they do not guide the tool performing the operation. The name implies further that the device is "fixed" in location, but this is not always the case. The field of assembly offers an excellent opportunity for the elimination of HOLD by the use of fixtures.

In collecting material for this thesis a survey was made of tool design texts, motion and time study texts, and periodicals dealing with or devoting space to both tool design and methods improvement. The purpose of the survey was to obtain general information on fixture design and on such design as would apply to methods improvement. Most of the tool design

6. Owen, H.F., Introduction to Tool Engineering; New York, Prentice Hall, Inc., 1948, pg. 111

20 establish a clearer concept of the limits of the

following definition is suggested. In the field of ma-

chine building, machine and other mechanical devices are

those which are designed to perform a specific function or

operation. Other devices for building and other

those are usually associated with provision for building with

in which the final result is the machine.

However, which may be defined as "device for building with

while an operation is being performed", are distinguished

from them by the fact that they do not build the final product

ing the operation. The same applies further that the device

is "fixed" in location, but this is not always the case. The

field of assembly offers an excellent opportunity for the

classification of work by the use of the device.

In collection material for this device a survey was made

of tool design books, articles and other texts, and period-

icals dealing with or devoted to tool design and

machine improvement. The purpose of the survey was to obtain

general information on the design and construction of

tools apply to machine improvement. Most of the tool design

texts consulted devoted some space to the principles of jig and fixture design. Also, in periodicals were found articles dealing with these principles, but there was not much information on the application of fixtures for methods improvement. The subject seemed worthy of further development.

From the tool design sources mentioned above, the common requirements of successful fixtures that were noted and felt to apply to methods improvement are:

- (1). Positive holding.
- (2). Simple construction, with few parts to move and wear and with parts attached so as to prevent their being misplaced.
- (3). Simple operation, holding accomplished rapidly and foolproof in that workpiece will fit in only one way.
- (4). Safety, as by avoiding sharp corners and giving the hands a free path for operation.
- (5). Provide the operator a clear view of workpiece.

To these may be added such physiological principles as:

- (1). Using stronger muscle groups, such as legs, with foot-operated vices.⁷
- (2). The action of pushing is less fatiguing than the action of pulling.⁸
- (3). Pressure by the hand is less fatiguing than the action of pressing the fingers and thumb together.⁹
- (4). Balancing hand patterns.
- (5). Making parts readily accessible.
- (6). Sliding of components to assembly is easier and faster than picking up and transporting.

The endeavor of this paper is to use the principles stated above as a guide to develop a check list which will

7. Mundel, M.E., Ibid, pg. 53

8. Holmes, W.G., Applied Time and Motion Study; New York, Roland Press Co., 1945, pg. 262

9. Holmes, W.G., Ibid, pg. 262

These conditions are applied to the evaluation of the
and before design. Also, in particular, the design
leading with these principles, but there was not much later-
action on the application of the principles for further improve-
ment. The subject seemed worthy of further development.
From the book design process mentioned above, the con-
sideration of successful design that was noted and
fail to apply to methods improvement are:

- (1). Positive holding.
 - (2). Simple construction, with few parts to make and
easy and with parts attached to a support
being held in place.
 - (3). Simple operation, holding assembled together
and disassembly in the workshop will be in the
one way.
 - (4). Safety, as by avoiding sharp corners and edges
the design a free path for operation.
 - (5). Provide the operator a clear view of operation.
- The design may be aided with psychological principles as:
- (1). Using stronger mental groups, such as lines, with
look-oriented views.
 - (2). The action of holding in hand holding the
action of pulling.
 - (3). Present of the hand in hand holding the
action of pressing the finger and thumb together.
 - (4). Holding hand picture.
 - (5). Holding parts together.
 - (6). Holding of components to assembly is essential
before then placing up and transporting.

The reviewer of this paper is to use the principles
related above as a guide to develop a design that will

-
7. Huxford, E.K., 1944, pp. 23
 8. Holmes, W.E., Applied Time and Motion Study; 1947.
 - Holmes Press Co., 1945, pp. 222
 9. Holmes, W.E., 1944, pp. 222

provoke thought on the part of the methods analyst in what is felt to be a logical sequence when approaching the problem of considering the therblig HOLD, especially when the purpose of such analysis is to eliminate it by means of the adoption of a fixture to perform the function currently being accomplished by hand. Further, some features are suggested for inclusion in the fixture and some illustrative examples of fixtures and their application are included. It is felt the field of application of this study will include primarily hand operations such as assemblies dealing with smaller, lighter workpieces, operations adapted to rapid hand movement and operations capable of being made bimanual. This study is not an attempt to eliminate the tool engineer and his function. After a perusal of the tool engineering texts it is felt the tool engineer dealing with fixture design concerns himself with holding workpieces for machining operations, while the methods analyst or motion and time study worker deals with the broader picture of industrial performance including simpler hand operations as exemplified by assembly work. It would be extremely difficult to draw a hard and fast line of demarkation between the two fields. Perhaps this is well illustrated by an idea expressed recently. "No reputable engineer would attempt to design a machine without strict observance of scientific facts, yet too often designs are completed in disregard for the physiological and psychological facts that govern the operator's

7

proceeds through on the part of the machine analyst in what is felt to be a logical sequence when approaching the problem of ascertaining the theoretical basis, especially when the purpose of such analysis is to illustrate in the course of the adoption of a system to govern the function of the machine. Further, some features are suggested for inclusion in the literature and some illustrative examples of features and their application are included. It is felt the field of application of this study will include primarily hand operations such as assemblies dealing with smaller, lighter workpieces, operations required in such hand movement and operations similar to using tools manually. This study is not an attempt to eliminate the tool engineer and his function. After a period of the tool engineering texts it is felt the tool engineer dealing with these operations connects himself with holding workpieces for machining operations, while the machine analyst or motion and time study worker deals with the broader picture of industrial performance including faster hand operations as exemplified by assembly work. It would be extremely difficult to show a hard and fast line of demarcation between the two fields. Perhaps this is well illustrated by an idea suggested recently. "The responsible engineer would attempt to design a machine without direct observation of scientific facts, but too often science and engineering is directed for the purpose logical and psychological facts that govern the operator's

behavior."¹⁰ This is further supported by the requirement of several large manufacturing companies that their tool engineers take an in-plant course in motion and time study and its application. Possibly the results of this study will be of use to workers in both fields of endeavor but it is thought those persons charged with methods analysis will be more likely to benefit from it.

10. Carmichael, Colin, "Editorial", Machine Design, March, 1950

behavior." This is further supported by the testimony of several large manufacturing companies that their pool engineers take an in-plant course in welding and this study and its application. Possibly the results of this study will be of use in various in-plant efforts of industry but it is thought those persons charged with waste analysis will be more likely to benefit from it.

PREPARATION OF CHECK LIST

The survey of texts and periodicals established principles but left the troublesome question of how to apply them. Reflection on this question led to the establishment of a check list which lists, in sequence, the factors related to the operation and workpiece which govern the need for the method of holding and which, if considered carefully, should lead to a clearer and more effective choice or design of a device to replace the hand. It is felt such a list will focus attention on these factors and thereby contribute to a better selection. For the sake of clarity examples are given to amplify as deemed necessary.

It may be well to consider some of the limitations of the application of HOLD. Of necessity the piece must be such that it can be moved and usually supported by a hand during the performance of work. Further, it is not worthwhile to prevent movement by means of the hand alone if much force acts on the piece. Also, if the piece or pieces in turn must be held rigidly in place the hand can not be used as effectively as a pneumatic cylinder or a foot operated vise.

Using the principles previously stated, the following check list was made for the consideration of HOLD:

The survey of design and production establishments was
 designed but left the freedom of design to the
 user. Attention to this question led to the establishment
 of a design list first, in response, the design related
 to the operation and response which served the need for the
 method of holding and which, if considered separately, should
 lead to a design and more effective design or design of a
 device to replace the hand. It is this which is the
 and attention on these factors and thereby contribute to a
 better solution. For the sake of clarity examples are given
 to supply as deemed necessary.

It may be well to consider some of the limitations of
 the application of HILL. Of necessity the place must be such
 that it can be moved and usually supported by a hand during
 the performance of work. Further, it is not worthwhile to
 prevent movement by means of the hand when it must force
 work on the place. Also, if the place or place is used
 must be held rigidly in place the hand can not be used as
 effectively as a pneumatic cylinder or a foot operated vice.
 Using the principles previously stated, the following
 must list was made for the consideration of HILL:

I. Resort to use of a device to eliminate HOLD.

- A. Will the use of a holding device permit balanced hand motions?
- B. Can dual fixture be used so both hands can do same things simultaneously?
- C. Can holding device be foot operated?
- D. Is it economical to resort to device?
- E. Does duration of HOLD warrant elimination?
- F. Does length of production run warrant the cost of making a device?
- G. Can a device already made be adapted?
- H. Can a device be made to serve this job and similar ones in the future?

II. Purpose of holding.

- A. Is axial movement prevented?
- B. Is lateral movement prevented?
- C. Is rotational movement prevented?
- D. Is a combination of these movements prevented?

III. Best position to hold the piece.

- A. Can piece be positioned so its weight helps hold it?
- B. What work areas must be made accessible to the worker's hands and view?
- C. Can all work areas be made accessible with piece in fixed position?
- D. If not, can they be properly presented by indexing the piece and/or fixture?

I. Before the use of a device to eliminate noise.

1. Will the use of a holding device prevent

eliminated hand movement?

2. Can hand strength be used as both hands are in

contact with the workpiece?

3. Can holding device be used to support

4. Is it economical to construct a device?

5. Does holding of hand prevent elimination

6. Does holding of workpiece prevent the work

of making a device?

7. Can a device already made be modified?

8. Can a device be made to move both up and down

that used in the future?

II. Purpose of holding.

1. Is axial movement prevented?

2. Is lateral movement prevented?

3. Is rotational movement prevented?

4. Is a combination of these movements prevented?

III. Best position to hold the piece.

1. Can piece be positioned so its weight helps

hold it?

2. What work areas must be made accessible to the

worker's hands and eyes?

3. Can all work areas be made accessible with piece

in fixed position?

4. If not, can they be properly presented by index-

ing the piece and/or fixtures?

III. Best position to hold the piece. (cont.)

- E. Can holding device be operated at the optimum angle of inclination?

IV. Selection of piece or part of piece to hold.

- A. Has piece a regular geometrical cross section?
- B. Is cross section for example:
1. Circular?
 2. Elliptical?
 3. Triangular?
 4. Rectangular?
 5. Octagonal?
- C. Can advantage be taken of cross section to adapt a wrench or similar device to do the holding?
- D. If shape is irregular, can a regular cross section be used advantageously and still support required areas?
- E. Can projections or other irregularities be used to help HOLD?
- F. Are projections strong enough to hold piece?
- G. Which parts of piece must be bridged?
- H. Can piece or pieces held be slid to assembly?

III. Best position to hold the plate. (cont.)

1. Can holding device be rotated so the specimen

angle is satisfactory?

IV. Position of plate or part of plate to hold.

1. Can plate be rotated to desired position?

2. Is cross section for specimen:

1. Circular?

2. Elliptical?

3. Triangular?

4. Rectangular?

5. Irregular?

3. Can advantage be taken of cross section to

adapt a special or similar device to do the

holding?

4. If angle is irregular, can a regular cross

section be used advantageously and still keep

part required straight?

5. Can projections or other irregularities be used

to hold firmly?

6. Are projections strong enough to hold plate?

7. Which parts of plate must be protected?

8. Can piece or pieces held be held in assembly?

V. Nature of the material in the workpiece.

- A. Is it hard? (Surface difficult to penetrate)
- B. Is it soft? (Surface easy to penetrate)
- C. Is it brittle? (Not capable of withstanding
much pressure on surface)
- D. Is it flexible? (Yields readily without per-
manent deformation)
- E. Is it fragile? (Easily broken)
- F. Is it a combination of above?

VI. Preservation of surface finish.

- A. May surface be marred?
- B. May surface be marred slightly?
- C. Must surface finish be preserved?
- D. How difficult is it to mar surface?

VII. Disposal of piece after completion of operation.

- A. Can drop disposal be used?
- B. Can fixture be used for succeeding operations(s)?
- C. Does piece need to be positioned in another
fixture?

V. Review of the material in the workshop.

1. Is it hard? (Students discuss in groups)

2. Is it soft? (Students discuss in groups)

3. Is it sticky? (Students discuss in groups)

4. Is it smooth? (Students discuss in groups)

5. Is it flexible? (Students discuss in groups)

6. Is it stretchy? (Students discuss in groups)

7. Is it light? (Students discuss in groups)

8. Is it a combination of above?

VI. Presentation of student ideas.

1. How many ideas do you have?

2. How many ideas do you have?

3. How many ideas do you have?

4. How many ideas do you have?

VII. Disposal of ideas after completion of workshop.

1. How many ideas do you have?

2. How many ideas do you have?

3. How many ideas do you have?

1987

DISCUSSION OF CHECK LIST

Probably the first consideration in analyzing the occurrence of the therblig HOLD is to determine whether or not it is advisable to eliminate it. Ultra short hand holding should not be eliminated since the time of loading and unloading the device would probably overbalance the time of holding and the cost of the device would not be returned. If, after the above consideration, it is deemed advisable to resort to a holding device a logical procedure should be followed in designing the fixture although each workpiece will be an individual case. Such a procedure should include, generally in the order named, consideration of the following steps:

1. Resort to use of a device to eliminate HOLD.

If the operation is such that both hands can perform useful work and in a balanced pattern, resort to a fixture is advisable. Further, if possible, both hands should do the same thing simultaneously. The hands can often be freed for productive work by the use of foot operated devices such as shown in Figure 1 and Figure 2.

Finally the first consideration in analyzing the performance of the results will be to determine whether or not it is advisable to eliminate the first stage of the analysis. It is suggested that the first stage of the analysis should not be eliminated since the view of loading and unloading the device would probably overestimate the time of holding and the cost of the device would not be reduced. If, after the above consideration, it is deemed advisable to report to a loading device a loading procedure should be followed in loading the device through each waterline will be an individual case. Such a procedure should include, generally in the order named, consideration of the following steps:

1. Report to the device to eliminate hold.
- If the operation is such that both hands are performing work and is a balanced system, however, to a device is advisable. Further, if possible, both hands should be the same thing simultaneously. The hands are often be fixed for productive work by the use of two special devices such as shown in Figure 1 and Figure 2.

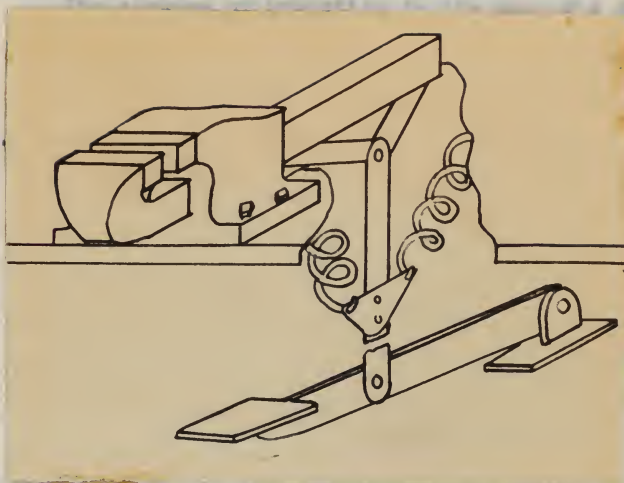


Fig. 1 Foot Operated Vise

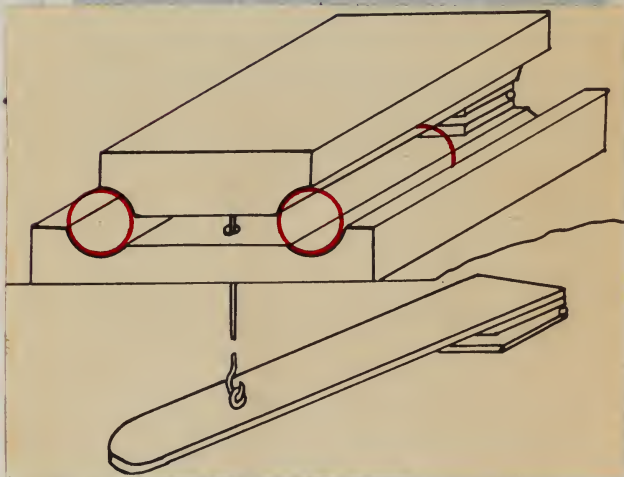


Fig. 2 Foot Operated Fixture For Holding Cylindrical Components

The top is spring loaded and the foot pedal may be detached to lay back out of the way.



Fig. 1. Front operated view



Fig. 2. Rear operated view for holding
cylindrical components

The top is closed inside and the top pocket can be

folded to the back end of the bag.

The economy of resorting to the use of a fixture should be considered and will involve the savings to be realized by such use. In addition, the length of run, or number of pieces to be produced will influence this decision. Worthy of note here is the cost of holding fixtures for hand operations. Usually the degree of accuracy and rigidity required is such as to permit making the fixture cheaply and from inexpensive materials, as illustrated in Figure 3.



Fig. 3. Wooden Fixture For Holding Threaded Sections Of Double Faucet During Assembly Of Apron and Valve Stems

Possibly a device already made can be adapted as by changing jaws and thus save the cost of making a new fixture. Also, looking ahead to future produc-

The economy of removing to the use of a thin-
 plate should be considered and will involve the ex-
 penses to be incurred by each user. In addition, the
 length of run, or number of plates to be produced
 will influence this decision. Many of these have
 to do with the holding times for some operations.
 Usually the nature of treatment and the type of material
 is such as to permit making the films directly and
 from inexpensive materials, as illustrated in Figure

3.



Fig. 3. Method of making thin films for holding times of
 10 to 15 minutes. The films are made from a solution of
 gelatin and water.

Usually a device already made can be adapted
 as by changing the size and shape of the
 a new fixture. Also, looking ahead to future prob-

tion may suggest similar pieces which could use the device if preparations are made now for adapting it.

2. Purpose of holding.

This involves establishing what the workpiece would do if not held. Many times the purpose will combine two or more of the listed movements. The purpose will suggest to some extent the area where support must be furnished. For example, axial movement could be prevented by primary support at the end and steadying on the sides.

3. Best position to hold the piece.

This will be influenced by (a) providing the worker a clear view of the piece, especially the area(s) on which he is to work, (b) giving his hands free access and (c) considering the tools he is to use. The number and location of work areas will control the position in which piece must be held and possibly whether or not it can remain fixed.

If it can be used, the horizontal or flat position offers the advantage of the piece's own weight helping hold it in position. Also, if such tools as powered screwdrivers are to be used they may be suspended overhead in a readily accessible position. If the piece must be vertical, possibly

and was found to be a very good one for the purpose.

3. Purpose of holding.

This involves establishing that the corporate
would be in one field. Many times the purpose will
define two or more of the listed movements. The
purpose will suggest to some extent the size of the
support must be furnished. For example, retail move-
ment could be governed by primary support in the
and creation of the other.

2. The following is a list of the names of the persons who have been appointed to the various committees of the Board of Directors of the American Telephone and Telegraph Company, for the year ending December 31, 1910:

will control the position in which please must be
is to use. The number and location of work areas
has a free room and (c) considering the tools he
area(s) on which he is to work, (b) giving his
worker a clear view of his place, especially the
This will be influenced by (a) positioning the

condition. If the place must be vertical, weight may be suspended overhead in a readily accessible locale as powered screwdrivers are to be used. Heavy weight helping hold is in position. Also, if position offers the advantage of the plane's end - If it can be used, the horizontal or flat position.

a device having a groove for the lower edge, guides for the sides, and a clamp on top may suffice and give rapid loading and unloading. (See Figure 4.)

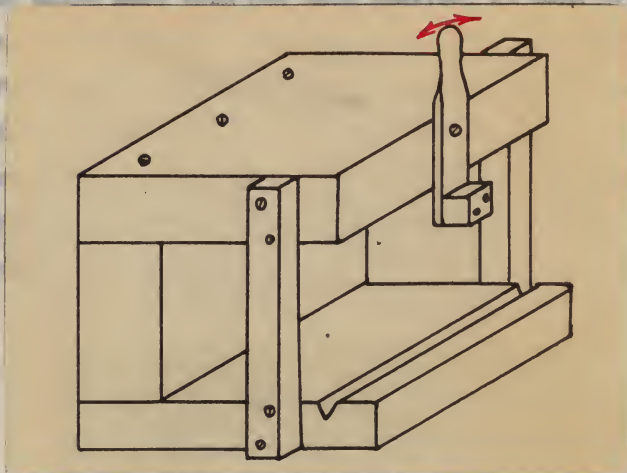


Fig. 4. Fixture For Holding Workpiece In Vertical Position

An intermediate position may be desirable to take advantage of increased operator efficiency at an optimum angle of inclination.¹¹ Intermediate positions may not require such clamping as indicated in Figure 4.

-
11. Halberstadt, H., Determination Of The Optimum Angle For A Work Area By Means Of Metabolic Measurement, Plus Instrumentation, Thesis, Purdue University, June, 1950

a device having a groove for the lower edge, which
 for the sides, and a sharp on top and bottom and
 give rigid loading and unloading. (See Figure 4.)



Fig. 4. Fixture for holding workpieces in
 vertical position

An intermediate position may be desirable in
 the absence of intermediate operator assistance at
 an extreme angle of inclination. ¹¹ Intermediate
 position may not require work clamping as indi-
 cated in Figure 4.

11. Belmont, R., Investigation of the Utility
of a Workpiece by Means of a Workpiece
Holder, Also Investigation, Design,
Truman University, Iowa, 1950

If the piece must be repositioned for several sub operations it complicates the design of the fixture. It may be wise to investigate the advisability of using more than one work station, at each of which are performed those sub operations which can be performed with the piece in each successive position. Should it be decided to reposition the piece at one work station for several sub operations such a device as is shown in Figure 5 or Figure 6 may be of use.



Fig. 5. Example Of An Indexing Fixture

Fixture shown in Figure 5 is used for holding meter frame for assembly of terminal brackets. Features of the fixture are: pins project into frame to position it and prevent rotation, notches on the edge of base, which with the detent on the left, stop and

If the glass must be represented for several
 and operations is completed the action of the
 glass. It may be also to illustrate the
 of being more than one action, it can be
 are performed these and operations which can be
 formed with the glass in each successive position.
 Should it be desired to represent the glass in
 were desired for several and operations such a
 glass as is shown in Figure 2 or Figure 3 may be
 used.



Fig. 6. Example of an existing device

Figure 6 shows in Figure 2 is used for holding
 and from for assembly of several elements. The
 of the device and glass is placed into them in
 position it and present position, which as the
 of glass, which is the detail on the left, and

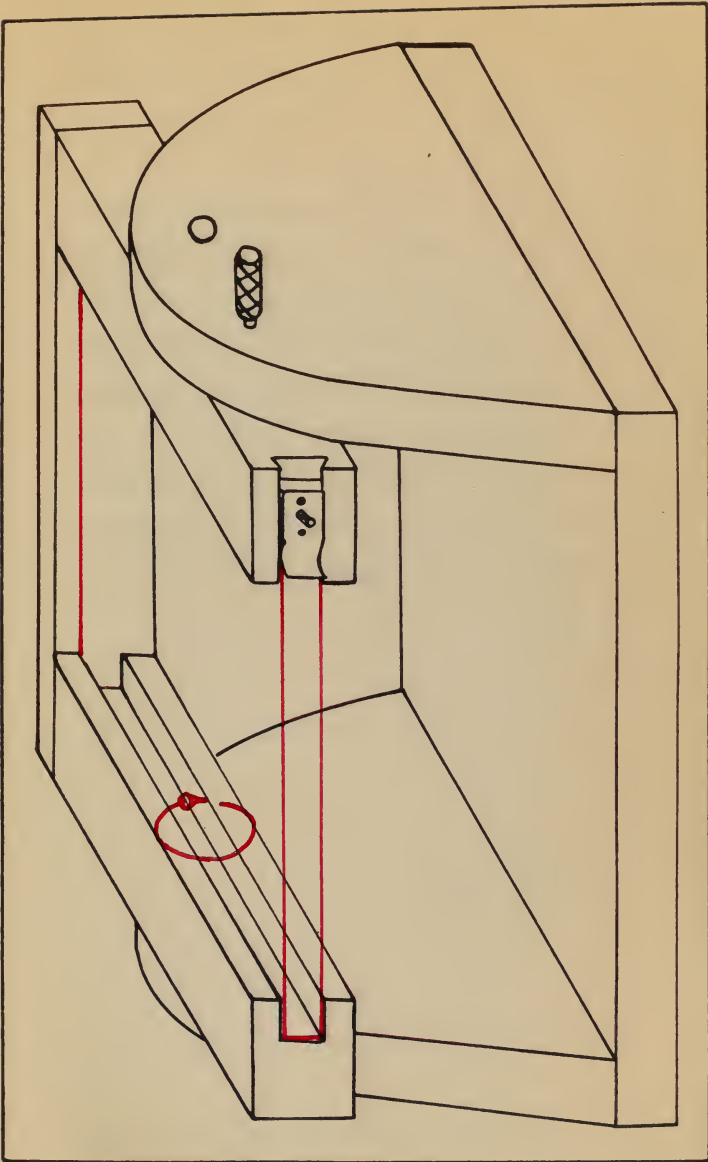


Fig. 6 Another Example Of An Indexing Fixture

hold piece in position for the presentation of successive work areas. A power driver is used to seat the bolts.

The fixture shown in Figure 6 could be used in holding a base plate to each side of which are to be assembled components, as by soldering. Retention of the plate in the desired positions is accomplished by means of a pin through the end support fitting into the rotatable frame. The base plate is held in the grooved frame by means of a sliding clip which facilitates loading and unloading. Details of the clip and bracket end are shown in Figure 7.

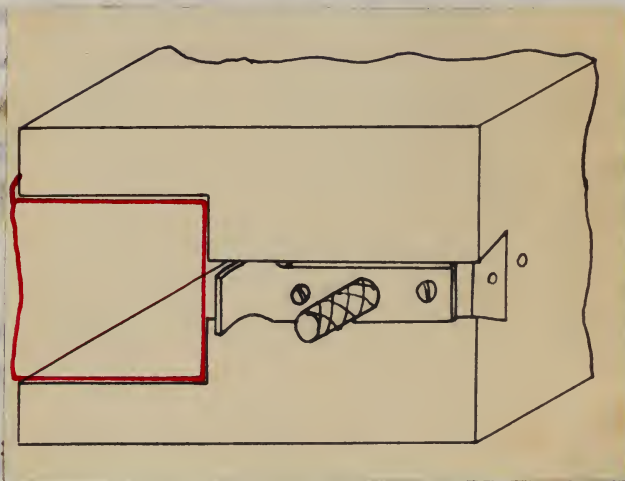


Fig. 7. Details Of Clip And Bracket End Of Fig. 6

hold place in position for the presentation of
 successive work items. A power driver is used to
 heat the plate.

The fixture shown in Figure 8 could be used to
 holding a base plate in position while it is being
 assembled component, as by soldering. Position of
 the plate in the heated position is accomplished
 by means of a pin through the end support fitting
 into the plate track. The base plate is held in
 the grooved frame by means of a sliding clip which
 facilitates loading and unloading. Details of the
 clip and bracket are shown in Figure 9.



Fig. 9. Details of Clip and Bracket and Base Plate.

The question of degree of fixation will arise under this consideration. For work which must be held rigidly in place, a foot operated vise would probably be best. (See Figure 1.) For other work more leeway is allowed and simplifies the fixture required.

4. Selection of piece or part of piece to HOLD.

It is often possible to take advantage of regular geometrical shapes by adaptation of conventional devices such as mating female wrench jaws.

If the shape is irregular it may be well to review the purpose of holding to see where on the work-piece it might be preferable to mechanically grasp it. This may permit taking advantage of regular cross sections for holding. Should this be impossible, the irregular cross section may be broken down into regular components, bridging the parts which it is deemed advisable not to support. (See Figure 8.)

At other times, if the irregularities are strong enough, they may be used to advantage to facilitate holding.

A broader consideration here is to weigh carefully the possible choices involved in determining which piece could most advantageously be held. The largest piece is not necessarily the best to hold.

The question of degree of fixation will arise under this consideration. For work which must be held rigidly in place, a fixed contact vice would probably be best. (See Figure 1.) For other work more loosely is allowed and sometimes the fixture required.

4. Selection of piece or part of piece to hold. It is often desirable to take advantage of regular geometrical shapes by adaptation of universal fixtures such as holding frames which jaws. If new shape is irregular it may be well to view the purpose of holding to see where on the work piece it might be preferable to mechanically grasp it. This may permit taking advantage of regular cross sections for holding. Should this be impossible, the irregular cross section may be broken down into regular components, dividing the parts which it is desired adaptable not to support. (See Figure 2.) At other times, if the irregularities are strong enough, they may be used to advantage to facilitate holding.

A proper consideration here is to weigh carefully the possible choices involved in determining which piece could most advantageously be held. The largest piece is not necessarily the best to hold.

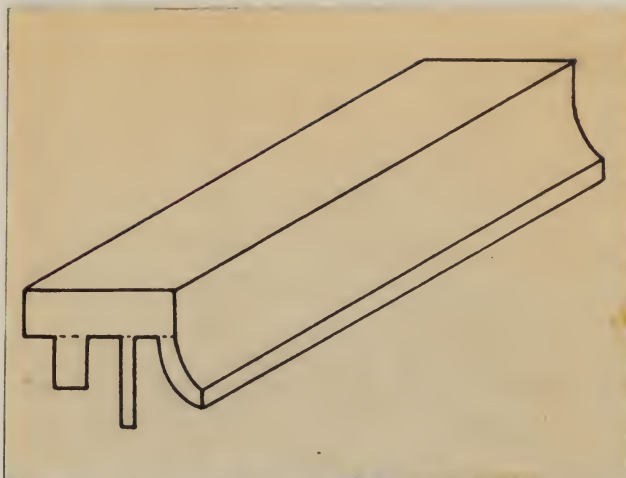


Fig. 8 Method Of Breaking Cross Section Into Regular Components



Fig. 9 Example Of Fixture For Two Handed Assembly



Fig. 8. Section of the wall of the
cave, showing the position of the
cave entrance.



Fig. 9. Section of the wall of the
cave, showing the position of the
cave entrance.

This consideration may lead to suggesting a revision of the operation as may be shown by the following example. An operation consisted of assembling to a brass cap a gasket and screw. Assembly in that order, holding the cap, was done at the rate of approximately 400/hour, or less. By holding the screw in a fixture and bimanually assembling to it in succession the gasket and cap, the rate was increased to as high as 750/hour. (See Figure 9 and Figure 10.)

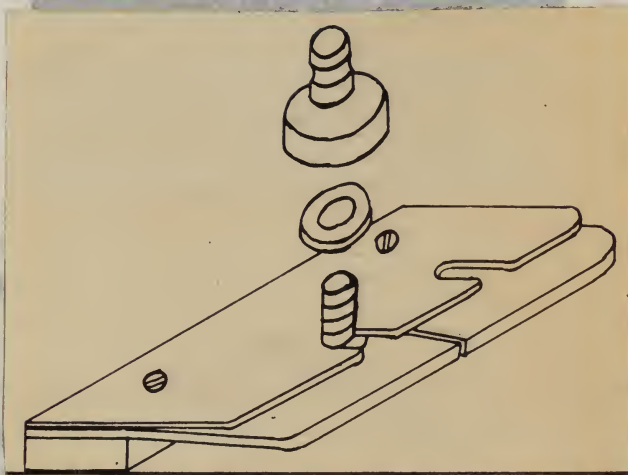


Fig. 10. Details Of Fixture Shown In Fig. 9

Where possible to do so, sliding of components to the assembly facilitates the operation since the efforts to grasp and release the piece are eliminated. Figure 11 shows a fixture for assembling a

This observation was made by observing a level-
 side of the operation as was shown by the fol-
 lowing example. An operation consisted of a series-
 of steps to a given step a given and given. These
 are in that order, holding the step, and then to the
 rate of approximately 400/1000, or less. By holding
 the screw in a fixture was physically assembling to
 it in association the process and cost, the rate was in-
 creased to as high as 450/1000. (See Figure 10.)

Figure 10.)

Fig. 10. Details of Figure 10 in Fig. 10

When possible to do so, all of the operations
 to the assembly facilities the operations shown in
 efforts to group and release the given are elimi-
 nated. Figure 11 shows a fixture for assembling a

metal washer and a snug fitting insulating sleeve to a bolt. The sleeves are first placed in the holes, the washers slid in on top and the bolts dropped through. A lever in front opens the device to allow the completed units to drop into a pan.



Fig. 11. Fixture Incorporating Sliding Of Components

Figure 12 shows a picture of a cardboard card which has been perforated to facilitate tearing into six parts. Holes previously stamped in the card are filled with buttons by pushing them through, while the edges of the holes are supported. Corner clips guide the card into the countersunk area it occupies while the buttons are positioned and assembled to it.

metal screen and a sand filling immediately above
to a hole. The screen is first placed in the
holes, the screen is then in on top and the holes
dropped through. A layer is then placed the device
to allow the compressed water to drop into a pan.



Fig. 11. Screen separating filling of
compressor

Figure 12 shows a picture of a cardboard case
which has been prepared to facilitate testing in-
to air pump. Holes previously stamped in the case
are filled with putty by pushing them through,
while the edges of the holes are supported. When
oil is put into the case the compressor will be
operated while the system is positioned and an-
alyzed to it.

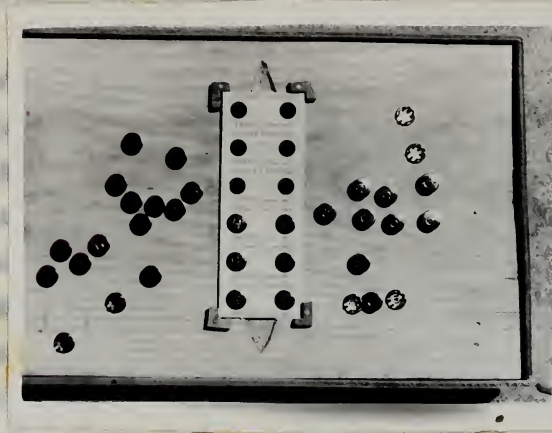


Fig. 12. Another Fixture Incorporating Sliding Of Components

5. Nature of the material in the workpiece.

The material from which the workpiece is made may be obtained from the specifications, prints or an examination of the piece itself. From this may be determined the nature of the material, which will in turn determine the amount of force that may be applied to the piece during holding and probably the kind of handling it must receive. As pointed out in the check list, combinations will exist.

Fig. 12. Another view of the workpiece showing the nature of the material in the workpiece.

The material from which the workpiece is made may be obtained from the specifications, or by an examination of the piece itself. From this may be determined the nature of the material, which will in turn determine the amount of force that may be applied to the piece during handling and probably the kind of handling it must receive. As pointed out in the work list, combinations will exist.

6. Preservation of surface finish.

Consideration of the surface finish and what may be done to it may lead to suggesting a new sequence of operations. For example, an enameled piece of wood to be held for the assembly of another piece might better be painted after assembly. If not, then lining of the fixture contact surfaces with rubber or other soft material may be resorted to.

If the surface may be marred, less care need be taken in the facing of bearing surfaces. They may be serrated or knurled to facilitate gripping.

For finishes permitting slight marring, flat contact surfaces may be used to good advantage. Possibly a facing of some substance softer than the piece may be needed, as for example, copper facing for steel pieces.

When the surface finish must be preserved, it can usually be accomplished without much difficulty, as by the use of a rubber pad for supporting chrome plated surfaces.

Of interest is the fact that under most circumstances the variation of a given dimension from piece to piece will decrease from rough to semi-finished pieces and from there to finished pieces which in turn reduces the need for including allowance for such variation in the holding device.

Reconditioning of the surface finish and how may be done so it may lead to satisfactory & low maintenance of operations. For example, an example of wood to be held for the assembly of machine pieces might better be painted after assembly. It is not, then lining of the finished surface with rubber or other soft material may be suggested.

For.

If the surface may be treated, then some need be taken in the design of bearing surfaces. They may be treated or treated to facilitate gripping. For finished surfaces slight errors, that contact surfaces may be used in good advantage. Possibly a lining of some substance other than the piece may be needed, as for example, copper facing for steel pieces. When the surface finish may be preserved, it can usually be accomplished without much difficulty, as by the use of a rubber pad for supporting elements placed vertically. Of interest in the fact that water may also cause the variation of a given dimension from piece to piece will decrease from rough to finished pieces and from those in finished pieces which in turn reduces the need for including allowance for such variation in the bearing device.

7. Disposal of piece after completion of operation.

Preservation of finish and nature of material will influence the requirements for method of loading and unloading the device and also the disposal of the piece after the completion of the operation, as might the advisability of positioning the assembly completed at one work station for use at the next. This may be exemplified by several workers doing the same operation feeding their work to one worker for the performance of the next operation.

Figure 10 shows an example of drop disposal.

Figure 8 shows an operation where one worker utilizes two fixtures to accomplish an assembly.

7. Report of plant after completion of operation.

Protection of finish and surface of material will influence the requirements for method of loading and unloading the device and also the disposal of the place after the completion of the operation, and might the advisability of positioning the machine completed at one work station for use at the next. This may be exemplified by several workers doing the same operation feeding their work to one worker for the performance of the next operation. Figure 10 shows an example of group assembly. Figure 11 shows an operation where one worker utilizes two fixtures to accomplish an assembly.

CONCLUSIONS

The proposed check list should prove to be a useful tool in effecting an improvement in work methods by aiding in the selection or designing of a device to eliminate HOLD. The principal benefits to be derived from the use of the check list result from the thinking provoked by a systematic analysis of the factors related to the occurrence of the therblig. Use of the proposed check list should result in such an approach to the problem.

The check list has not been validated by use, but should be reliable since it is based on accepted principles of fixture design and motion economy. By the use of the proposed check list these principles may be systematically applied to the therblig HOLD.

In order that any check list be most effective it must be conscientiously applied. The proposed check list, if so applied, should give the methods analyst a guide for dealing with the problem of eliminating HOLD.

CONCLUSIONS

The proposed check list should prove to be a useful tool in effecting an improvement in work methods by eliminating the selection or designing of a device or eliminating the principal benefits to be derived from the use of the check list result from the thinking provided by a systematic analysis of the factors related to the assessment of the results. Use of the proposed check list should result in such an approach to the problem.

The check list has not been validated by use, but should be reliable since it is based on accepted principles of fixturing design and motion economy. By the use of the proposed check list these principles may be systematically applied to the fixturing design.

In order that any check list be most effective it must be occasionally applied. The proposed check list, if so applied, should give the methods engineer a guide for eliminating the problem of eliminating inefficiency.

BIBLIOGRAPHY

1. Mundel, M.E., Systematic Motion and Time Study; Prentice-Hall Inc., New York, 1947
2. Barnes, R.M., Motion and Time Study; John Wiley & Sons, New York, 1949
3. Ischinger, E.Jr., An Analysis of Some Differences Between One and Two Handed Work, Master's Degree Thesis, Purdue University, June, 1950
4. American Technical Society, Modern Shop Practice; Chicago, 1940, Vol. 4
5. Owen, H.F., Introduction to Tool Engineering; Prentice-Hall, Inc., New York, 1948
6. Holmes, W.G., Applied Time and Motion Study; Roland Press Co., New York, 1945
7. Carmichael, C., Machine Design; March, 1950
8. Halberstadt, H., Determination of the Optimum Angle For A Work Area By Means of Metabolic Measurement, Plus Instrumentation, Master's Degree Thesis, Purdue University, June, 1950.

BIBLIOGRAPHY

1. Handel, E.T., *Synthetic Nylon and Terephthalic Acid*, Wiley Inc., New York, 1947.
2. Handel, E.T., *Nylon and Terephthalic Acid*, Wiley & Sons, New York, 1949.
3. Lehninger, A.L., *An Analysis of Some Nitrogenous Compounds*, and the United States, *Nitrogen's Nitrogen*, University, Iowa, 1940.
4. American Technical Society, *Nitrogen's Nitrogen*, Chicago, 1940, Vol. 4.
5. Gunn, E.T., *Introduction to Terephthalic Acid*, Wiley Inc., New York, 1949.
6. Wolman, W.G., *Applied Terephthalic Acid*, Wiley & Sons, New York, 1949.
7. Lehninger, A.L., *Nitrogen's Nitrogen*, University, Iowa, 1940.
8. Lehninger, A.L., *Introduction to Terephthalic Acid*, Wiley Inc., New York, 1949.

Thesis
K51

Kirk

A check list for the
therblig hold.

13260

Thesis
K51

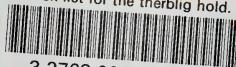
Kirk

A check list for the
therblig hold.

13260

thesK51

A check list for the therblig hold.



3 2768 001 02798 0

DUDLEY KNOX LIBRARY